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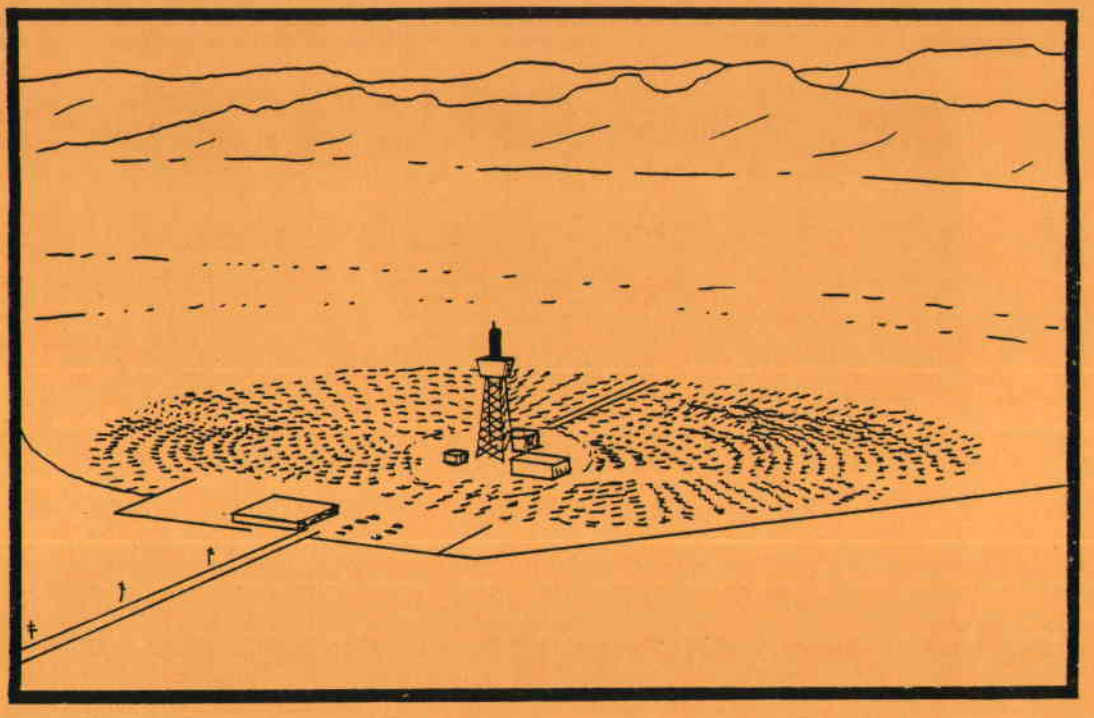
Wildlife Interactions At Solar One: Final Report



By: Michael D. McCrary, Robert L. McKernan,
Patricia A. Flanagan, and William D. Wagner

Report for Research and Development
Southern California Edison Company
Rosemead, California

January, 1984

WILDLIFE INTERACTIONS AT SOLAR ONE: FINAL REPORT

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SOUTHERN CALIFORNIA EDISON COMPANY
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EXECUTIVE SUMMARY

From May 1982 through May 1983 Solar One, the world's largest solar energy power plant, and a surrounding area of approximately 150 ha were surveyed for possible wildlife interactions. The spring 1982 survey indicated that avian and insect incinerations and avian collisions were two areas of concern which needed further investigation. The purpose of this final report is to provide the results of the study period from December 1982 through May 1983 and to report on the overall impact of the facility on wildlife.

During 102 days of study 107 bird species and over 22,000 individuals were counted in the vicinity of Solar One. This high bird use of the Solar One study area in comparison to the sparse population of most of the Mojave desert is a result of the close proximity of Solar One to extensive (53 ha) ponds and active agricultural fields.

Almost all cases of incineration at Solar One involved aerial insects. These incinerations appear as small flashes of light within the standby points (four areas in close proximity to the receiver where the beams of sunlight are concentrated, accompanied by a brief trail of white vapor. In most cases the identity of the actual species involved could not be determined, but most incinerations probably involved dragonflies, wasps, bees, and butterflies.

Unlike insects, the incineration of birds in the standby points is a rare occurrence. During the 14 month period from April 1982 through May 1983, only 6 bird incinerations were known to have occurred at Solar One. This indicates that mortality from incinerations is

less than one bird per month.

Avian collisions with plant structures, especially heliostat mirrors were more frequent than incinerations. During this study at least 27 birds died from collisions. Portions of another 27 birds were also found within the grounds of the facility. Although some of these may have died from collisions, many appeared to have been killed by an undetermined predator.

None of the bird species recorded in the area of Solar One are listed as threatened or endangered by either the U.S. Fish and Wildlife Service or California Department of Fish and Game.

Considering all known avian fatalities regardless of cause of death in the 14 month period from April 1982 through May 1983, 60 birds may have died as a direct result of Solar One operation. This low mortality in relation to the high bird use of the study area indicates that the impact of Solar One on birds after initial construction is minimal. The results of this study suggest that, to insure the minimal impact of this technology on birds, future solar central reciever power plants in the Mojave desert should not be sited in close proximity to open water or other areas of high bird use.

ACKNOWLEDGMENTS

We thank Joseph Reeves (Research and Development, Southern California Edison Co.), Terry Sciarrotta (SCE Wildlife Project Manager), Paul Skvarna (SCE Site Manager of Solar One), Douglas Elliott (U.S. Department of Energy Project Director), and all other Solar One personnel for their valuable assistance on this project. Particular thanks goes to Buzz Sawyer of the SCE Cool Water Plant for sharing his knowledge of bird distribution in the area of the Solar One facility and Chris Nagano, entomolgist at the Los Angeles County Museum of Natural History, for his time and expertise.

INTRODUCTION

The ever increasing demand for electricity in the United States and the potential for future oil shortages has led to the commercial development of technologies to utilize alternative energy sources such as solar, wind, and geothermal. Even though these developments are designed to take advantage of renewable resources, as with most technologies, they also have the potential for impacting the environment.

As part of Southern California Edison's (SCE) goal to incorporate alternate and renewable energy resources in its overall power production, in 1979 the United States Department of Energy, in conjunction with SCE and the Los Angeles Department of Water and Power, initiated the construction of Solar One, the world's largest solar energy power plant in the Mojave desert of southern California (Figure 1). This solar central receiver power plant consists of an array of 1,818 heliostats (Figure 2) which concentrate sunlight on a centrally located, tower-mounted boiler (Figure 3) where steam is produced to drive a turbine. When not directed at the tower, some or all of the heliostats are focused on four small areas of the sky around the tower (Figure 4). Temperatures produced in these standby points are variable, depending on the number of heliostats focused on them; the operating temperature of the receiver itself is approximately 600°C (1,100°F). Until the construction of Solar One, the use of the sun's energy to produce electrical power had never been attempted at this level, and the environmental hazards of a fully operational solar generating power plant are unknown.

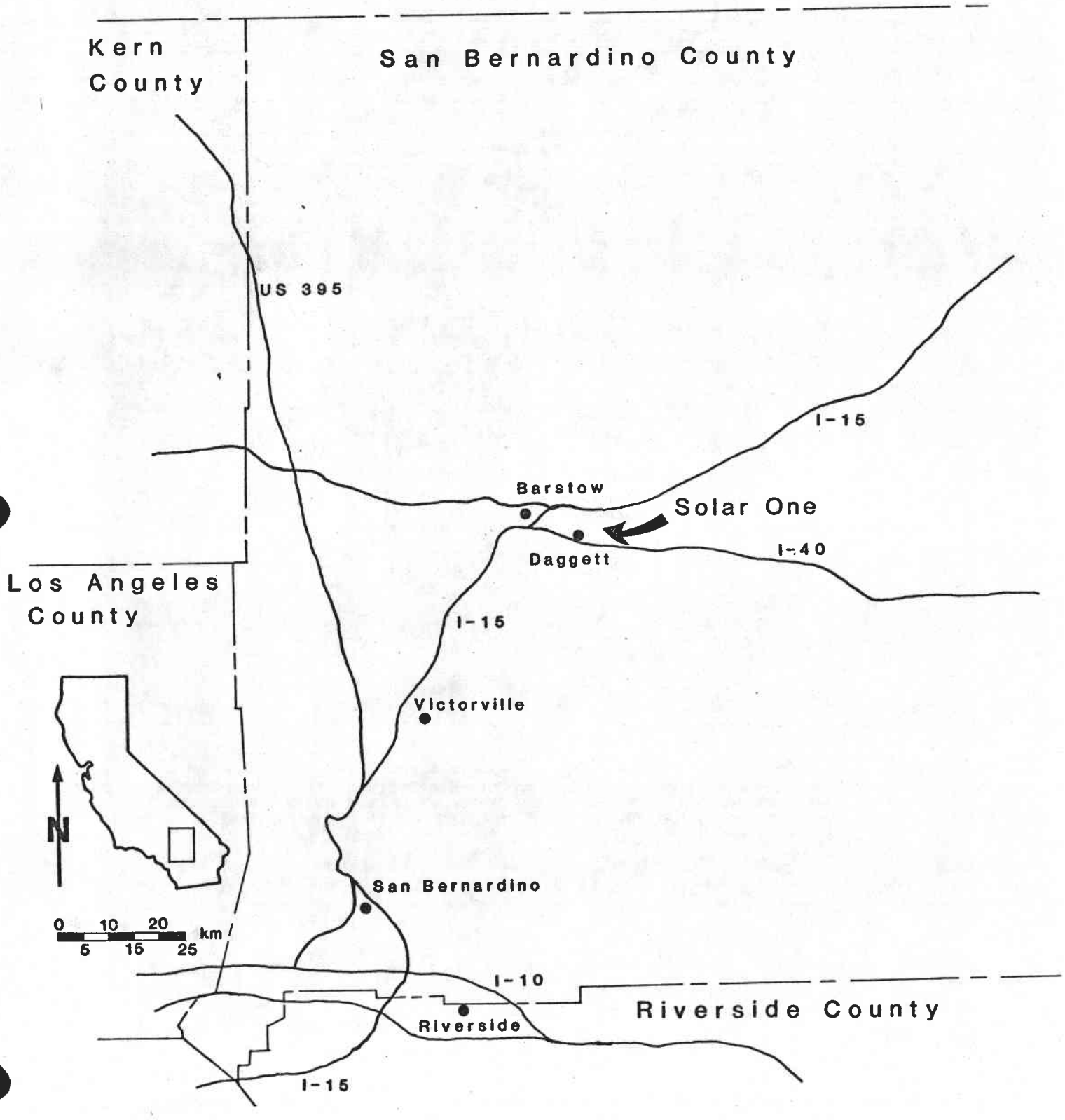

Figure 1. Location of Solar One in the Mojave Desert of southern California.

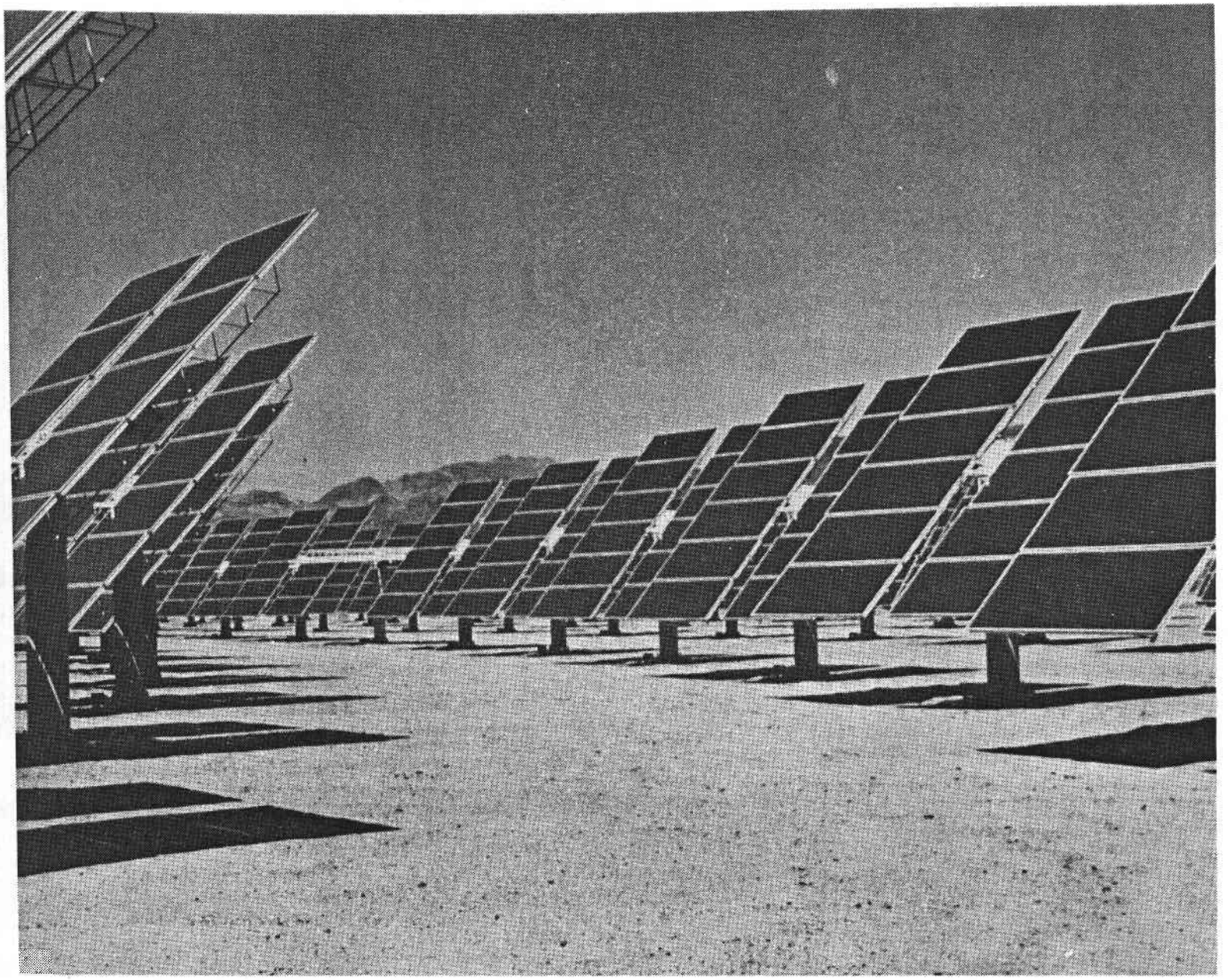

Figure 2. Solar One heliostat field.

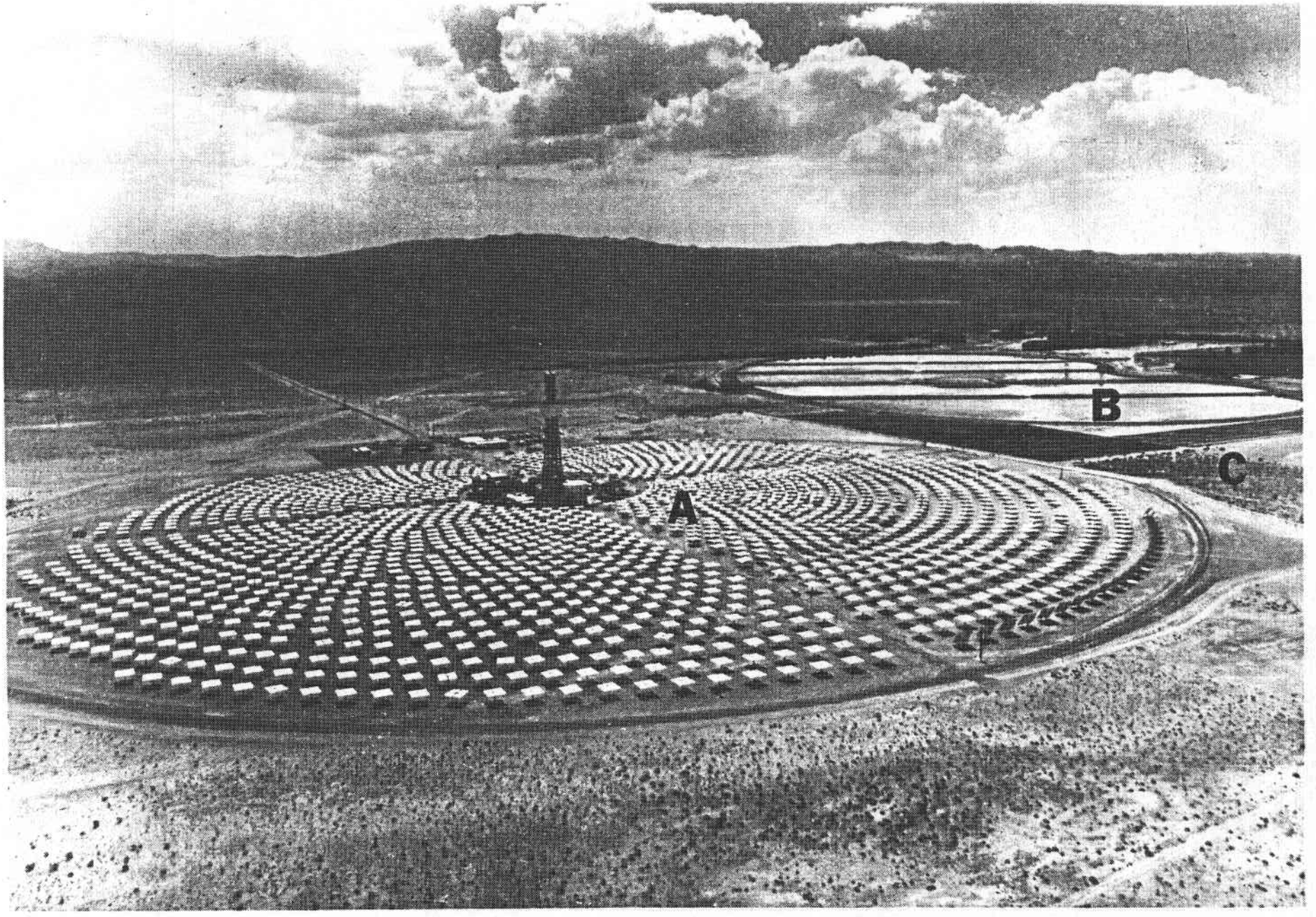

Figure 3. Aerial view of A) Solar One facility, B) evaporation ponds, C) agricultural areas. View is to the SSW.

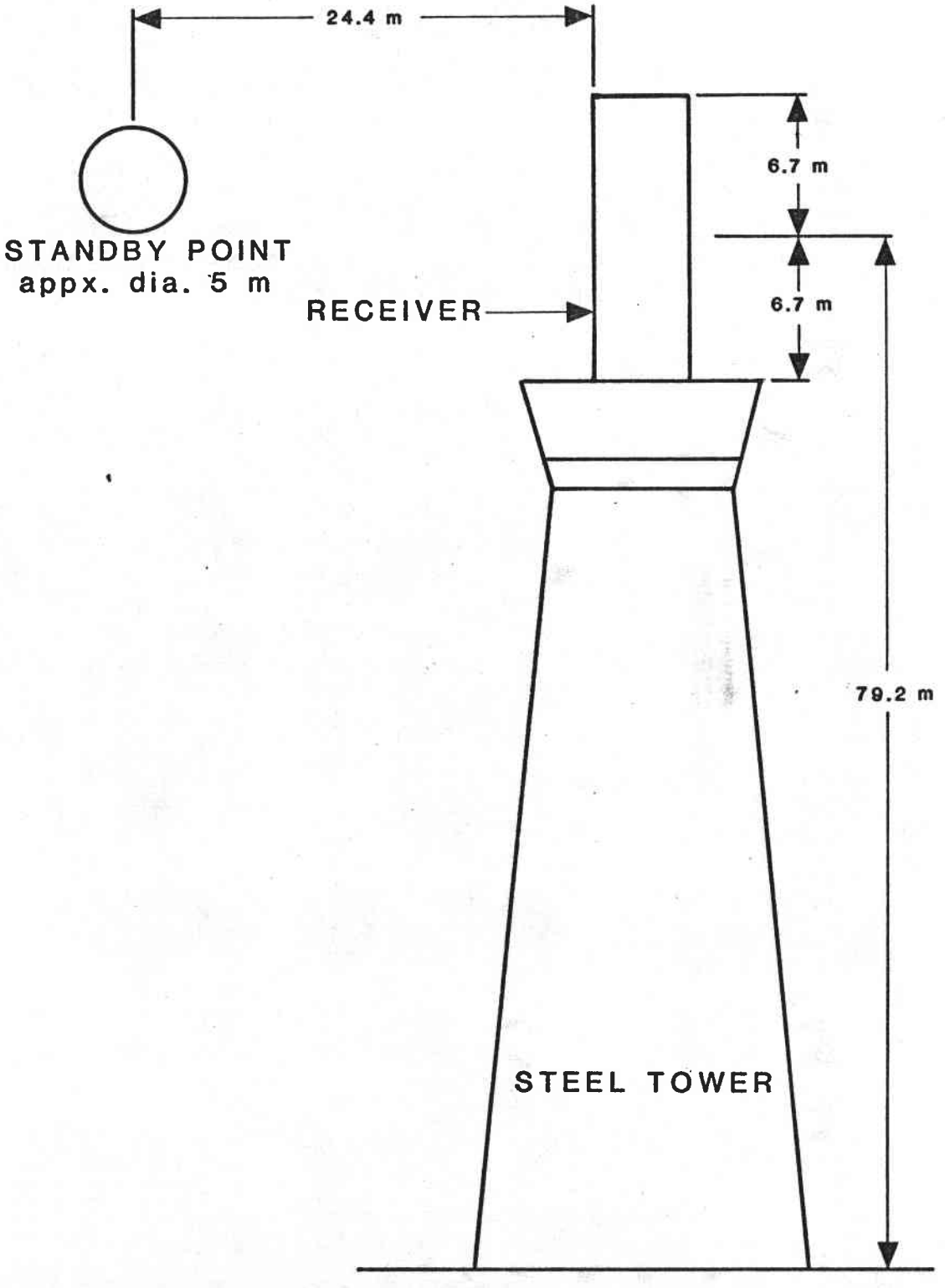

Figure 4. Diagram of the Solar One receiver tower and the position of one of the four standby points.

After Solar One became operational in April 1982, plant employees noticed bright flashes of light occurring with some frequency in the standby points. To determine the cause of these flashes, in May 1982 SCE initiated a short term wildlife survey of the facility through the Los Angeles County Museum of Natural History. The purpose of this initial study was to pinpoint areas of potential biological concern in regard to plant operation and to establish a methodology to determine the actual impact of the facility on wildlife. The results of the spring 1982 survey indicated that avian and insect incinerations resulting from the extreme heat concentrated by the heliostats in the standby position and avian collisions with mirrors as two areas of concern which needed further investigation (McKernan et al. 1982).

Subsequent observations of wildlife/Solar One interactions were conducted from September 1982 through May 1983. The results of the fall 1982 study period have previously been reported in an interim report to SCE (Wagner et al. 1983). The purpose of this final report is to provide the results of the study period from December 1982 through May 1983 and to report on the overall impact of the facility on wildlife.

STUDY AREA

Solar One is located in the Mojave desert, 4 km east of Daggett, California (24 km east of Barstow) in San Bernardino county. The location of Solar One was selected because of the high number of

cloudless days characteristic of the Mojave desert which facilitate plant operation and the close proximity of the site to an existing generating station. The dominant desert plant community in this area is creosote bush scrub, (Larrea divaricata), although the disturbed habitat immediately surrounding the Solar One facility consists mainly of abandoned agricultural fields and salt bush scrub (Atriplex polycarpa). This native vegetation recolonized the area after it was cleared for agriculture in 1953. Additional agricultural fields, which have remained unused since 1961, occur along the west side of the facility. These fields are slowly being invaded by weedy plants such as pigweed (Chenopodium album), filaree (Erodium circutarium), and Russian thistle (Salsola iberica). Actively cultivated alfalfa fields still exist along the east side of the facility.

Of particular importance to birds is the close proximity of Solar One to extensive (53 ha) evaporation ponds located at the nearby SCE Coolwater Power Plant (Figure 4). These ponds attract numerous water-bird species during spring and fall migration.

METHODS

During the initial spring 1982 study period, the Solar one facility was visited on 6 different occasions of approximately 3 days each. During these initial visits, we conducted non-specific surveys of both the facility grounds (32 ha) and a surrounding area of approximately 150 ha, including the evaporation ponds and adjacent agricultural

fields, for any possible wildlife interactions at Solar One. We paid particular attention to birds, as they were the most obviously abundant vertebrates near the plant and seemed to have the greatest chance of being affected by plant operation. We censused the ponds once per day for approximately 2 hours in the early morning, after which we surveyed the agricultural fields surrounding the facility. We also performed daily searches through the heliostat field, around the central receiver tower, and along the peripheral fence for any evidence of biological interaction with the facility.

Based on the results of the spring 1982 study, research was resumed in September 1982. A more extensive field procedure was employed during the September 1982 through May 1983 study period. This methodology was designed to more intensively document the impact of the facility on birds and insects and derive an estimation of the biological significance of this impact. During this period the plant was visited on 34 occasions of approximately 3 days each. The methodology used during each visit consisted of a survey of both the evaporation ponds and the fields between Solar One and the ponds for birds and other wildlife on at least 2 of the 3 mornings for approximately two hours. During this survey we especially concentrated on two rows of introduced tamarisk trees (Tamarix ramosissima), each approximately 1 km in length, and a small artificial seep overgrown with introduced weedy plants which attracts numerous birds.

The central receiver tower and standby points were observed from

several vantage points, depending on time of day, for avian and insect incinerations and behavioral responses to the facility. This sampling was conducted once or twice per day for approximately 60 min, during which time we recorded the number of individuals and species of birds flying over the plant, flight directions, location in relation to the receiver tower, and any apparent behavioral responses to the facility. An attempt was also made to estimate the rate of insect incinerations, if any were occurring.

Systematic searches for dead or injured birds were conducted once per visit through the heliostat field, around the receiver tower, and along the peripheral fence. These searches were facilitated by the lack of vegetation and level ground around the heliostats. In conjunction with these searches, we conducted an experiment to determine the rate of scavenger removal from the heliostat field. In spring 1982 we placed 3 birds, ranging in size from a Mourning Dove (Zenaida macroura) to a House Sparrow (Passer domesticus), 120 m apart in the northwest quadrant of the facility. An additional 3 birds were placed just outside the plant. In fall 1982 we placed 7 birds, ranging in size from a Western Gull (Larus occidentalis) to a House Finch (Carpodacus mexicanus), 120 m apart in the northwest quadrant of the facility. An additional 6 birds were placed just outside the plant. The status of these birds was periodically updated for approximately 30 days after placement.

RESULTS

During 102 days of study from May - June 1982 (18 days) and September 1982 - May 1983 (84 days), we recorded 107 bird species (Appendix 1) and over 22,000 individuals in the immediate area of Solar One. Figure 5 shows the seasonal fluctuation in avian species diversity and relative abundance in the vicinity of Solar One. The mean number of birds recorded in all daily counts was 314 birds ± 22.8 SE, and the mean number of species was 16.7 species ± 0.6 SE. Mean relative abundance (440 birds ± 50.1 SE) was highest during winter 1982-83 (Dec-Feb), when from 148-891 birds were recorded per count. However, this period was characterized by the lowest species diversity (mean per count = 13.7 ± 0.78 SE), with most individuals composed of only 4 species, Canada Goose (Branta canadensis), Northern Pintail (Anas acuta), Horned Lark (Eremophila alpestris), and House Finch.

Spring 1982 was also characterized by a high mean relative abundance (392 birds ± 83.4 SE), especially for Eared Grebes (Podiceps nigricollis), shorebirds, and swallows. The two highest daily counts during the study occurred on 11 and 12 May 1982 (1,037 and 1,040 birds, respectively). However, unlike the winter months, the highest species diversity occurred in spring 1982 (mean per count = 23.6 ± 0.73 SE). On the other hand, the lowest number of birds were recorded during spring 1983 (mean per count = 174 ± 18.2 SE) when most daily counts were below 200 individuals. Species diversity was also lower

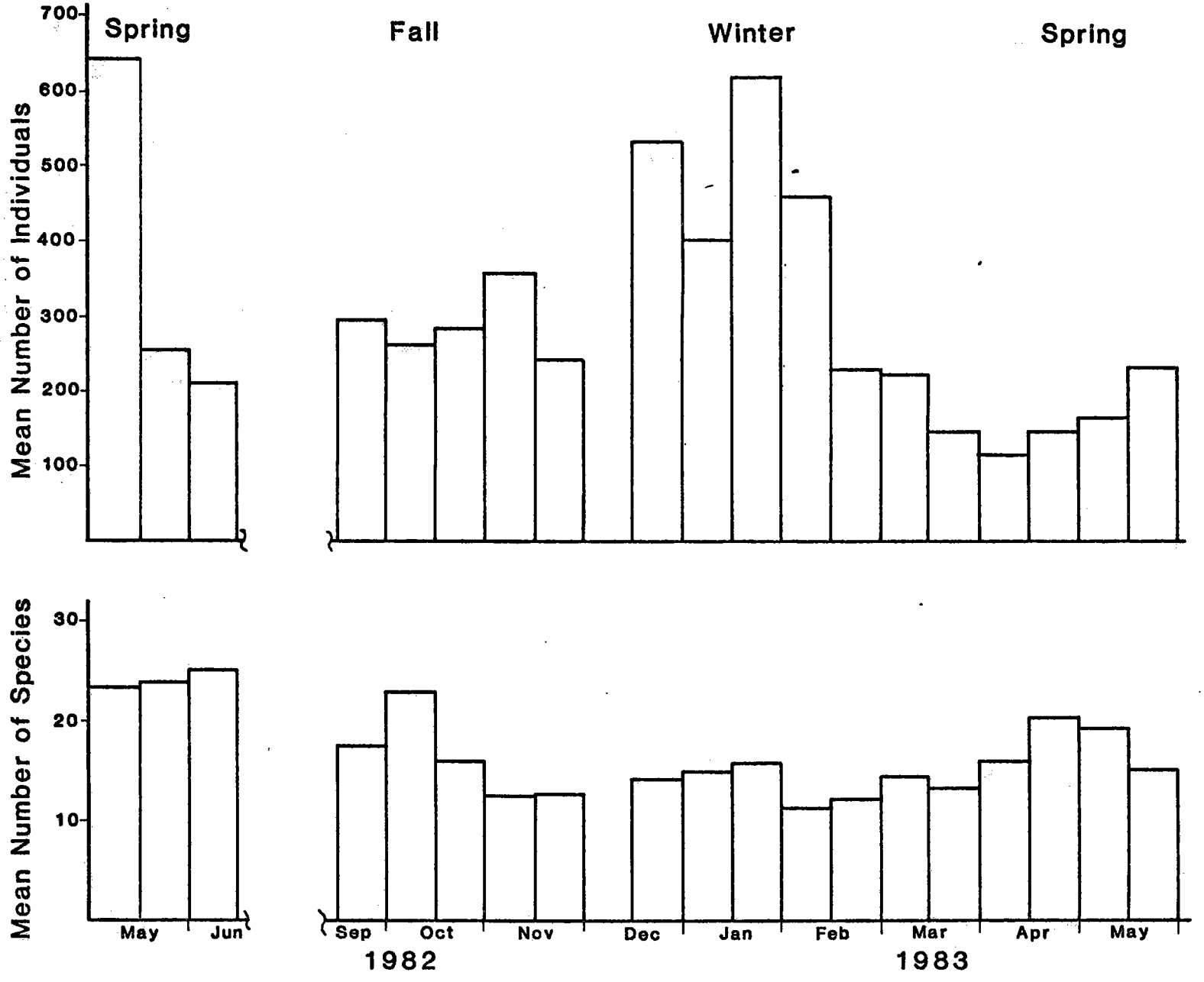

Figure 5. Seasonal bird use of the Solar One study area.

in this period (mean per count = 16.2 ± 0.73 SE). The difference between spring 1982 and spring 1983 indicates that extreme fluctuations in bird utilization of the Solar One site may occur from year to year. The mean number of birds recorded in fall 1982 was 278 ± 20.1 SE and the mean number of species was 16.8 ± 1.3 SE.

Most avian species recorded at Solar One were migrants and only 15 species are resident to the area, with Horned Larks, European Starlings (Sturnis vulgaris), and House Finches the most common nesting birds. None of the bird species recorded in the area of Solar One (Appendix 1) are listed as threatened or endangered by either the U.S. Fish and Wildlife Service or California Department of Fish and Game.

Of the habitats surveyed in this study, the evaporation ponds were the most heavily utilized by birds. Seventy-five species were recorded at the ponds, and 48 species were recorded only at the ponds; waterbirds usually made up the majority of daily counts throughout much of the study.

Fewer birds used the agricultural areas and fields surrounding Solar One or the grounds of the facility itself. Except for Mourning Doves, almost all of these species were passerines, mainly Horned Larks, European Starlings, and House Finches. Because of the lack of suitable habitat in the vicinity of Solar One, most passerines occurred in very low numbers.

Raptors in the study area were rare during both spring 1982 and 1983, with only 5 Red-tailed Hawks (Buteo jamaicensis), 3 American Kestrels (Falco sparverius), and 1 Prairie Falcon (Falco mexicanus) recorded during those periods. Raptors were more numerous in fall and winter, when 8 species (Appendix 1) and 166 individuals (often the same birds) were observed during daily counts. Only one raptor, the American Kestrel, may breed in the immediate vicinity of Solar One.

Receiver Tower and Standby Point Observations

Although we did not record actual rates of movement over Solar One during spring 1982, aerial foragers (swifts and swallows) were frequently observed flying over the heliostat field and receiver tower. These birds crossed over the heliostat field while foraging for insects which were abundant at that time. Over 900 individuals of 5 species (Appendix 1) were recorded flying over or near the facility during daily counts. These birds were most common during mid-May. Other species commonly flying over or found within the facility during this period included Mourning Doves, Horned Larks, and House Finches.

During fall and winter 1982-83 when we began making systematic observations of the airspace over the plant, many more species were observed flying over the heliostat field and near the central tower. The mean rate of movement across the plant for all observations was 39 birds/hour, with most birds (68%) flying from 10 - 50 m or between the top of the heliostats and the lower portion of the receiver

tower. The number of flights was highest during the winter months (Figure 6) and much lower during fall and spring.

The most common species flying over the plant were blackbirds, mainly Red-winged (Agelaius phoeniceus) and Brewer's Blackbirds (Euphagus cyanocephalus). Early morning and evening flights of blackbirds were recorded daily over Solar One, with most flights occurring from 10 - 50 m in altitude. These birds primarily utilized the irrigated agricultural fields and were only infrequently seen at the evaporation ponds or Solar One grounds. From mid-morning on, these birds foraged within the agricultural fields performing occasional short flights while remaining close to the ground.

Waterfowl, consisting mainly of Canada Geese and Northern Pintails, usually arrived at the ponds from the northeast in the early morning hours. Their flight paths were usually to the south of the heliostat field, but on several occasions waterfowl were observed flying directly over the plant. We occasionally observed flocks of Canada Geese and other waterfowl swerving to avoid standby points.

Raptors were also seen flying or soaring over the heliostat field during fall and winter, although usually well above the receiver tower and standby points. Occasionally, a Prairie Falcon, Golden Eagle (Aquila chrysaetos), or Red-tailed Hawk flew within 10-50 m of the hazardous standby points with no obvious avoidance maneuvres or change in flight direction.

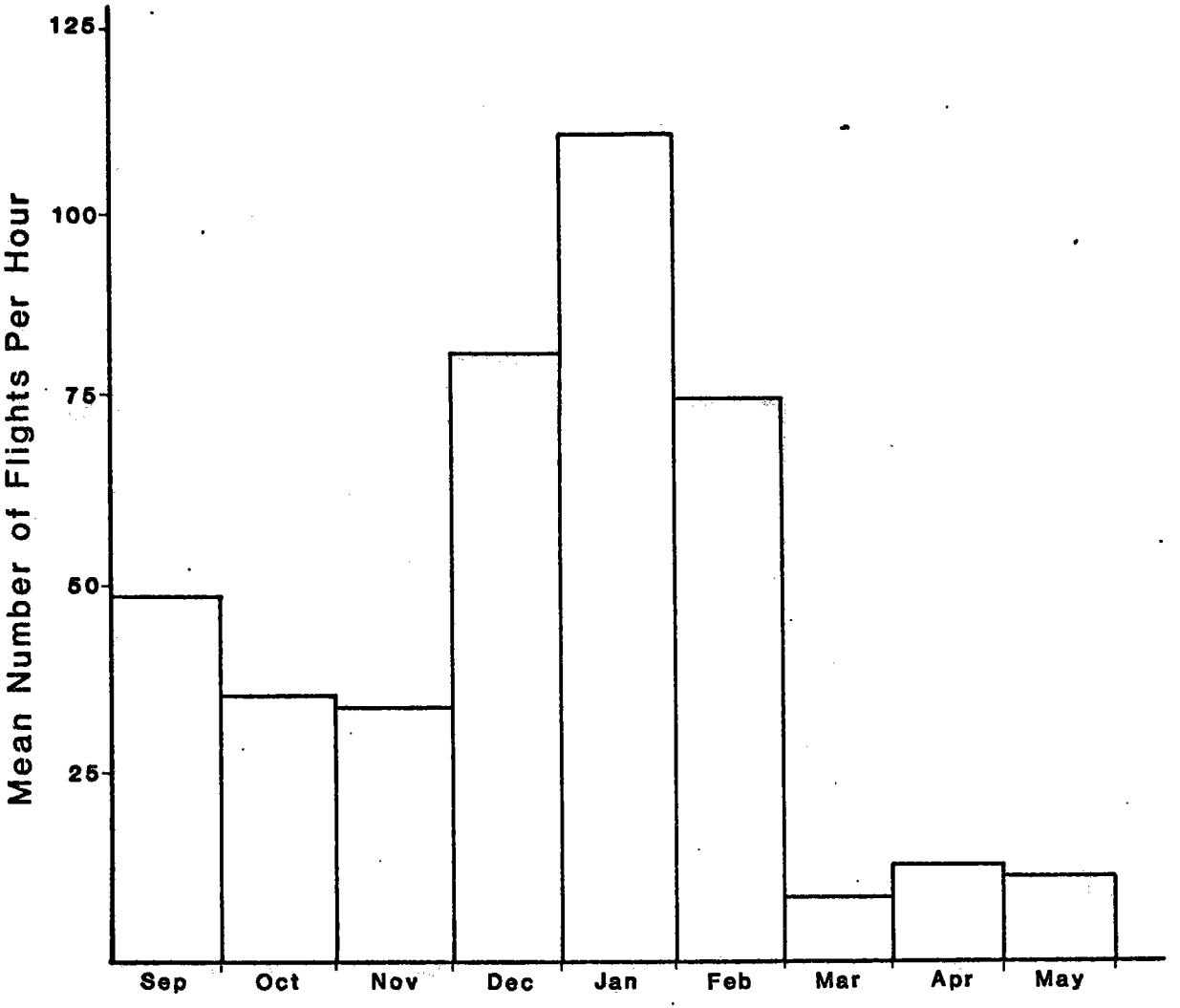

Figure 6. Seasonal occurrence of bird flights over Solar One, 1982-83.

Horned Larks, Water Pipits (Anthus spinoletta), White-crowned Sparrows (Zonotrichia leucophrys), and House Finches commonly foraged in weedy fields adjacent to Solar One and perched on the fence surrounding the facility. They also moved through the heliostat field foraging or loafing under the mirrors but always remained at very low elevations in flight.

Solar One Related Animal Mortality

We determined that almost all cases of incinerations at Solar One involved aerial insects. These incinerations appear as small flashes of light within the standby points, accompanied by a brief trail of white vapor. In most cases we were unable to identify the actual species involved, since little remains after incineration. The insect parts that were identifiable included dragonflies, wasps, bees, and butterflies, and no species of insects known to be under state or federal protection are anticipated or known to occur in the immediate vicinity of Solar One (C. Nagano pers. comm.). On one occasion, approximately 75 dragonflies were found around the base of the control tower, all of which were intact with no visible sign of incineration (T. Sciarrotta pers. comm.).

Insect incinerations may occur at any time of day when the sun is shining, depending on the number of mirrors concentrated on the standby points. Periods of heavy incineration are sporadic in occurrence depending on both the presence and intensity of the standby

points and the occurrence of large numbers of insects in the airspace over the plant.

Although we did not conduct systematic observations of the standby points during spring 1982, insect incinerations were probably the most frequent during this period. From occasional observations, the rate of incineration may frequently have been as high as 400-500 insects/hr. This corresponds with the more frequent occurrence and greater intensity of the standby points during the early months of plant operation.

During more systematic observations of the airspace over the plant from September 1982 through May 1983, standby points were present in only 19 of 71 observation periods. This reduction in the occurrence of standby points corresponded with a low incidence of insect incinerations. Insect incinerations were recorded on only 10 of the 19 periods when the standby points were present. Heavy incinerations occurred on 8 October 1982 and 4 May 1983 when we recorded 7,059 insects/hr and 632/hr, respectively. No incinerations were recorded during December, February, and March, and only light to moderate incinerations occurred during other periods (8-234 insects/hr).

Unlike insects, the incineration of birds in the standby points is a rare occurrence. During the 14 month period from April 1982 through May 1983, only 6 bird incinerations (5 confirmed and 1 probable) were recorded at Solar One (Table 1). This indicates that

Table 1. Avian mortality at Solar One, 1982-83.

Incinerations		Collisions	
Species	Number of individuals	Species	Number of individuals
		Spring 1982	
Vaux's Swift (Chaetura vauxi)	1	American Kestrel (Falco sparverius)	1
White-throated Swift (Aeronautes saxatalis)	1	Mourning Dove (Zenaida macroura)	5
hummingbird sp.	1	European Starling (Sturnis vulgaris)	2
Barn Swallow (Hirundo rustica)	1		
		Fall 1982	
Yellow-rumped Warbler (Dendroica coronata)	1	Blue-winged Teal (Anas discors)	1
Sparrow sp.	1	Red-necked Phalarope (Phalaropus lobatus)	1
		hummingbird sp.	1
		Savannah sparrow (Passerculus sandwichensis)	3
		White-crowned Sparrow (Zonotrichia leuchophrys)	1
		Dark-eyed Junco (Junco hyemalis)	1
		Yellow-headed Blackbird (Xanthocephalus xanthocephalus)	1
		Blackbird sp.	1
		Winter 1982-83	
no observed incinerations		Western Meadowlark (Sturnella neglecta)	1
		White-crowned Sparrow	1
		Spring 1983	
no observed incinerations		Eared Grebe (Podiceps nigricollis)	1
		Yellow-rumped Warbler (Dendroica coronata)	1
		MacGillivray's Warbler (Oporornis tolmiei)	1
		Red-winged Blackbird (Agelaius phoeniceus)	1
		Tricolored Blackbird (Agelaius tricolor)	2
		Yellow-headed Blackbird	1

mortality from incinerations is well under one bird per month.

Three of the 6 incinerations occurred in May 1982 and involved three species, all of which were aerial foragers. Although we did not see these incinerations take place, the cause of death was immediately apparent because of the heavily singed flight and contour feathers (Figure 7). These deaths corresponded with the presence of large numbers of birds foraging in the airspace over the heliostat field and an extensive period of heliostat testing during which the standby points were more frequently present. A fourth severly burnt bird (hummingbird sp.) was found by plant employees in April 1982 prior to the initiation of this study.

Two incinerations occurred during the 3 months of monitoring in fall 1982 (1 confirmed and 1 probable). This lower mortality corresponds with a period of low relative avian abundance (Figure 5) and lower periods of standby point occurrence. More importantly, no swifts and only 34 swallows were observed in the vicinity of the plant during observations from September through November and none were recorded actually flying over the plant itself.

In spite of the high relative abundance (Figure 5) and greater number of flights (Figure 6) during that period, apparently no incinerations occurred during the winter months (Dec. - Feb.). The reasons for this are probably similar to the above; no aerial foragers were present in the vicinity of the plant during the winter study period

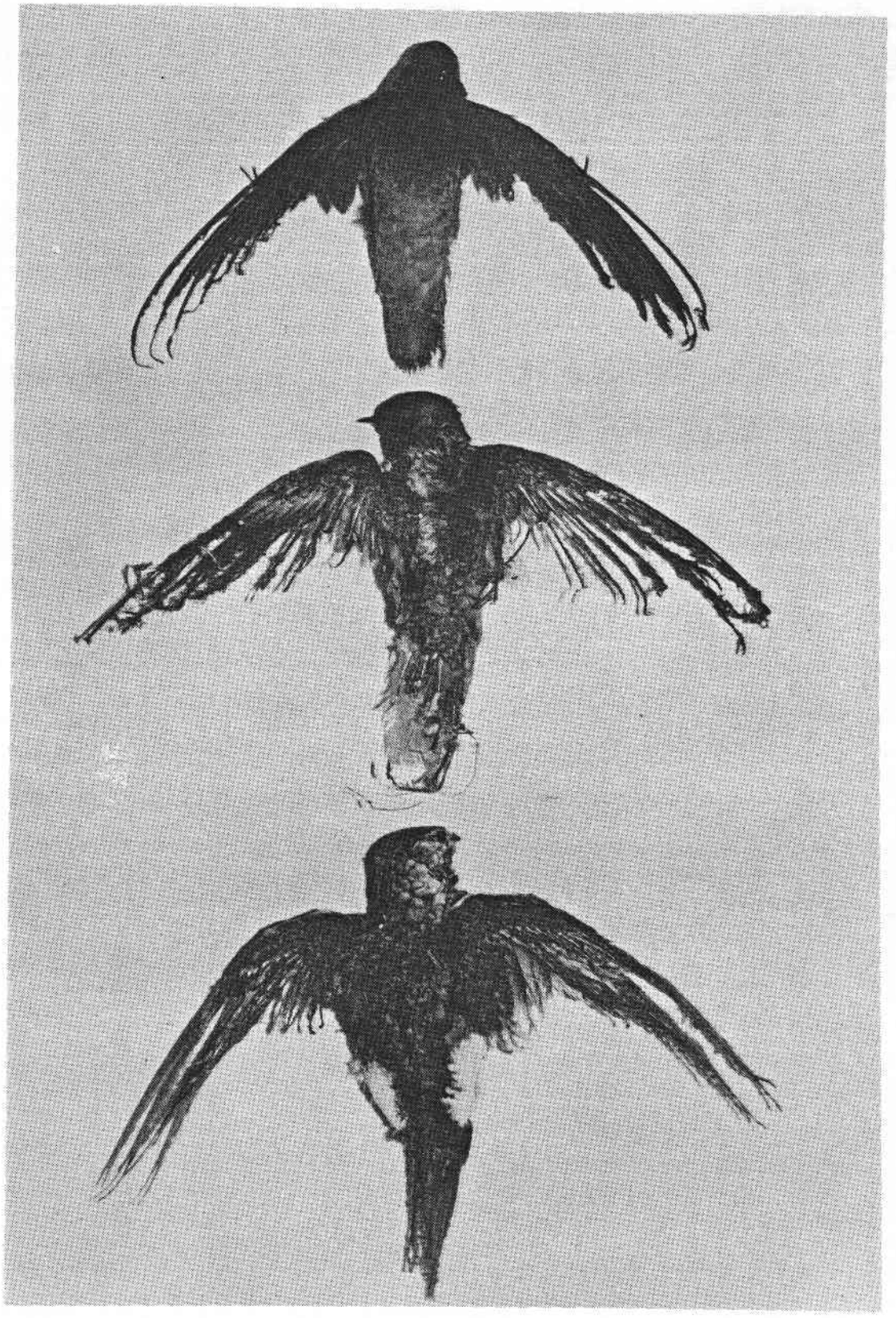

Figure 7. Three of the 6 known avian incinerations at Solar One. Top to bottom: Vaux's Swift (Chaetura vauxi), Barn Swallow, (Hirundo rustica), White-throated Swift, (Aeronautes saxatalis).

and fewer heliostats were focused on the standby points. Similarly, the lack of incinerations in spring 1983 was probably related to the relative absence of standby points and, unlike spring 1982, less than 100 swifts and swallows were noted in the vicinity of Solar One during daily counts.

Collisions

Avian collisions with plant structures, especially heliostats, were more frequent at Solar One than incinerations. During the 14 month period from April 1982 throught May 1983, at least 27 birds died from collisions (Table 1), mainly with the heliostats. In most cases the cause of death was determined by the presence of broken mandibles and/or wings. For unknown reasons, only two confirmed collisions occurred in winter 1982-83, which was characterized by a high abundance of birds in the area of Solar One (Figure 5), while the remaining fatalities were more equally distributed through the other seasons.

Portions of another 27 birds (usually wings and heads) were also found within the grounds of the facility (Table 2). Although some of these birds probably died from collisions, the cause of death in these cases could not be determined; there was no indication of incineration in any of these specimens. Many of these birds appeared to have been killed by an undetermined predator or scavenged.

Table 2. Undetermined bird fatalities at Solar One, May 1982 - May 1983.

Species	Number of individuals
Eared Grebe (Podiceps nigricollis)	10
American Coot (Himantopus mexicanus)	2
Bonaparte's Gull (Larus philadelphia)	1
Mourning Dove (Zenaida macroura)	1
Horned Lark (Eremophila alpestris)	3
European Starling (Sturnis vulgaris)	2
Brewer's Blackbird (Euphagas cyanocephalus)	4
House Finch (Carpodacus mexicanus)	4
Total	27

Scavenger Removal

The results of the scavenger removal experiment in both spring and fall 1982 indicate that the disappearance of bird fatalities between our searches of the Solar One grounds was not a significant problem. Only one of the 6 birds placed around the facility in spring 1982 was believed to have been taken by an animal and that bird was outside the fence. The removal of birds between searches may have been somewhat more of a problem in fall 1982, when one of the 7 birds placed within the heliostat field on 17 September disappeared the first day. However, the other 6 birds were still in the same position through the end of the 30 day removal study. By October 6 one of the 6 birds placed outside the facility had been partially consumed and two had disappeared. These limited results indicate that the rate of removal from the facility itself was only 10% per month, while outside the plant, the removal rate was approximately 44% per month.

DISCUSSION

Throughout this study it was apparent that the Solar One facility is situated near an important man-made oasis for migratory birds. The special attractiveness of this site to birds is the presence of a large (53 ha), man-made, water impoundment and irrigated agricultural fields, both of which produce an abundance of insects. Naturally occurring open water sources in the Mojave desert are rare and usually ephemeral in occurrence, while the man-made ponds near Solar One are present year round. Creosote bush scrub, which characterizes most of the undisturbed portions of the Mojave desert, is usually only sparsely inhabited by birds. Tomoff (1974), during a multi-season study in Arizona, found that avian community structure in creosote bush scrub habitat usually consists of less than 20 species. McKernan et al. (in prep.), working in California, found that their creosote bush scrub study plot was utilized by less than 30 species throughout the year, only 8 of which nested in the area. On the other hand, we recorded 107 species in the vicinity of Solar One, 15 of which breed in the area. This high diversity is a direct result of the availability of open water and the agricultural activity in the Solar One study area. Of the 107 species recorded, 48 were waterfowl and shorebirds observed at the cooling ponds; 27 of the remaining species also occurred at the ponds. The few rows of trees near the plant provide foraging and roosting for many migrant passerines and the agricultural fields attract numerous blackbirds, Horned Larks, and sparrows.

Other than the effects of initial plant construction, the major impact of Solar One operation is on aerial insects and, to a much lesser extent, birds. Although we were not able to calculate actual mortality, many thousands of insects may frequently be incinerated during the warmer months of the year. The severity of these incinerations is dependent on both the abundance of insects in the air space over the plant and the presence and intensity of standby points. The heaviest periods of incineration occurred during spring and fall 1982 when extensive testing of plant operation was still being conducted. These periods were characterized by an abundance of aerial insects and the frequent presence of intense standby points. Although we have no direct evidence to support this, it seems likely that insects may actually be attracted to the bright standby points resulting in more incinerations than would normally occur by chance.

Avian incinerations, although extremely rare in occurrence, seemed to be especially a function of the presence and intensity of standby points and the abundance of aerial foragers (swifts and swallows) in the vicinity of the plant. Three of the 6 birds incinerated during the 14 month period from April 1982 through May 1983 were aerial foragers, all of which occurred in May 1982. Another bird was also incinerated in spring 1982, a period of high avian abundance, especially of swifts and swallows, and extensive heliostat testing, resulting in the more frequent occurrence of intense standby points.

Despite an abundance of birds in the study area and numerous bird

flights over the plant, no incinerations were detected during winter 1982-83. This appears to be a function of the absence of aerial foragers in the vicinity of the plant and higher plant efficiency, resulting in the lower occurrence and intensity of standby points.

We found that avian mortality from collisions with heliostats and other plant structures is much more frequent in occurrence than incinerations. The 27 confirmed avian collisions were relatively evenly distributed throughout all seasons except winter 1982-83, when only two known fatalities were found. This pattern of mortality has little apparent relationship to any aspect of plant operation and is probably a function of the number of birds in the vicinity of the plant. An additional 27 birds were found within the grounds of the facility for which death could not be determined. Although it is highly probable that a portion of these birds also died from collisions, many appeared to have been carried to the plant by an undetermined predator or scavenger.

Avian collisions are an inevitable by-product of almost all man-made structures. A partial list of structures known to be responsible for collisions includes radio towers, smoke stacks, cooling towers, fences, and telephone poles (see Avery et al. 1980). Tall structures, such as the Solar One receiver tower, and reflective surfaces, such as the heliostats, are especially prone to collisions. As many as 80 million birds in the United States alone may die annually from collisions with windows and mirrored glass buildings (Klem 1979), and it is

not surprising that collisions with heliostats occur on a somewhat regular basis at Solar One.

Considering all known avian fatalities regardless of cause of death at Solar One in the 14 month period from April 1982 through May 1983 (60 birds) in relation to the high bird use of the Solar One study area, the impact of the plant on birds after construction is minimal. Taking into account the possibility that 10-44% of fatalities may have been removed from the plant before being observed only slightly increases the significance of the incidence of mortality.

The results of this study suggest that, to minimize their impact on birds and insects, future solar central receiver power plants in the Mojave desert should not be sited in close proximity to open water or agricultural fields. The variety of species involved in avian mortality at Solar One indicates that caution should be taken when siting a plant near populations of rare, threatened, or endangered species, such as the Yellow-billed Cuckoo (Coccyzus americanus) and Least Bell's Vireo (Vireo belli pusillus), which may occur in very localized situations in the Mojave desert. Since Solar One is only a 10 MW pilot plant, the scope of future projects involving hundreds of megawatts will require several thousand heliostats and much taller receiver towers. The greater magnitude of these plants may produce non-linear relationships in mortality when compared to this pilot plant study and extrapolations should be made with caution.

CONCLUSIONS

During 82 days of study from May - June 1982 and September 1982 - May 1983, we recorded 109 bird species and over 22,000 individuals in the immediate area of Solar One. Almost all of these birds were migrants and none are presently considered threatened or endangered by federal or state law.

Creosote bush scrub, which characterizes most of the undisturbed portions of the Mojave desert in the vicinity of Solar One, is usually only sparsely inhabited by birds. The special attractiveness of the Solar One site is the presence of a large, man-made water impoundment in an area of contiguous, low profile desert habitat. This, in conjunction with both abandoned and currently irrigated agricultural fields adjacent to Solar One create an ideal situation for migratory birds in the otherwise harsh conditions of the Mojave desert.

Other than the effects of initial plant construction, the major impact of Solar One operation is on aerial insects and, to a much lesser extent, birds. Many thousands of insects may frequently be incinerated during the warmer months of the year. The severity of incinerations appears to be dependent on, not only the abundance of insects in the air space over the plant, but also the presence and intensity of standby points. No threatened or endangered insects are known or expected to occur in the area of Solar One.

Only 6 birds were known to have been incinerated during the 14 month period from April 1982 through May 1983 indicating the rarity of this form of mortality at Solar One. Swifts and swallows foraging for insects over the plant during spring appear to be especially vulnerable to incineration probably because of their rapid and erratic flight behavior.

Avian mortality from collisions with heliostats and other plant structures is more frequent in occurrence than incinerations. This form of mortality can be expected to occur with most man-made structures, and reflective surfaces, such as the heliostats, are especially prone to collisions. However, the rate of collisions at the Solar One pilot plant (27 birds from May 1982 - May 1983) does not indicate a significant problem.

Overall mortality was minimal at the Solar One pilot plant in relation to the high bird and insect use of the area around the plant. To insure a minimized impact, future solar central receiver power plants in the Mojave desert should not be sited in close proximity to open water or agricultural fields. Because of the variety of species involved in avian mortality at Solar One, caution should also be taken when siting a plant near populations of rare, threatened, or endangered species.

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Appendix 1. Avian species observed in the vicinity of Solar One, May 1982 - May 1983.

Eared Grebe	*Podiceps nigricollis*
Western Grebe	*Aechmophorus occidentalis*
American White Pelican	*Pelecanus erythrorhynchos*
Double-crested Cormorant	*Phalacrocorax auritus*
Great Blue Heron	*Ardea herodias*
Great Egret	*Casmerodius albus*
Snowy Egret	*Egretta thula*
Snow Goose	*Chen caerulescens*
Canada Goose	*Branta canadensis*
Green-winged Teal	*Anas crecca*
Mallard	*Anas platyrhynchos*
Northern Pintail	*Anas acuta*
Blue-winged Teal	*Anas discors*
Cinnamon Teal	*Anas cyanoptera*
Northern Shoveler	*Anas clypeata*
Gadwall	*Anas strepera*
American Wigeon	*Anas americana*
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Lesser Scaup	*Aythya affinis*
Bufflehead	*Bucephala albeola*
Red-breasted Merganser	*Mergus serrator*
Ruddy Duck	*Oxyura jamaicensis*
Turkey Vulture	*Cathartes aura*

Appendix 1. continued

Northern Harrier	*Circus cyaneus*
Sharp-shinned Hawk	*Accipiter striatus*
Red-tailed Hawk	*Buteo jamaicensis*
Ferruginous Hawk	*Buteo regalis*
Golden Eagle	*Aquila chrysaetos*
American Kestrel	*Falco sparverius*
Prairie Falcon	*Falco mexicanus*
Gambel's Quail	*Callipepla gambelli*
American Coot	*Fulica americana*
Snowy Plover	*Charadrius alexandrinus*
Semipalmated Plover	*Charadrius semipalmatus*
Killdeer	*Charadrius vociferus*
Black-necked Stilt	*Himantopus mexicanus*
American Avocet	*Recurvirostra americana*
Greater Yellowlegs	*Tringa melanoleuca*
Spotted Sandpiper	*Actitis macularia*
Whimbrel	*Numenius phaeopus*
Marbled Godwit	*Limosa fedoa*
Sanderling	*Calidris alba*
Western Sandpiper	*Calidris mauri*
Least Sandpiper	*Calidris minutilla*
Baird's Sandpiper	*Calidris bairdii*
Dunlin	*Calidris alpina*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Wilson's Phalarope	*Phalaropus tricolor*

Appendix 1. continued

Red-necked Phalarope	*Phalaropus lobatus*
Bonaparte's Gull	*Larus philadelphia*
Ring-billed Gull	*Larus delawarensis*
California Gull	*Larus californicus*
Herring Gull	*Larus argentatus*
Caspian Tern	*Sterna caspia*
Forster's Tern	*Sterna forsteri*
Black Tern	*Clidonias niger*
Mourning Dove	*Zenaida macroura*
Greater Roadrunner	*Geococcyx californianus*
Great Horned Owl	*Bubo virginianus*
Vaux's Swift	*Chaetura vauxi*
White-throated Swift	*Aeronautes saxatalis*
Belted Kingfisher	*Ceryle alcyon*
Northern Flicker	*Colaptes auratus*
Western Wood-Pewee	*Contopus sordidulus*
Black Phoebe	*Sayornis nigricans*
Say's Phoebe	*Sayornis saya*
Western Kingbird	*Tyrannus verticalis*
Horned Lark	*Eremophila alpestris*
Tree Swallow	*Tachycineta bicolor*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Cliff Swallow	*Hirundo pyrrhonota*
Barn Swallow	*Hirundo rustica*
Common Raven	*Corvus corax*

Appendix 1. continued

Verdin	*Auriparus flaviceps*
Bewick's Wren	*Thryomanes bewickii*
House Wren	*Troglodytes aedon*
Ruby-crowned Kinglet	*Regulus calendula*
Black-tailed Gnatcatcher	*Polioptila melanura*
Hermit Thrush	*Catharus guttatus*
Water Pipit	*Anthus spinoletta*
Loggerhead Shrike	*Lanius ludovicianus*
European Starling	*Sturnus vulgaris*
Warbling Vireo	*Vireo gilvus*
Orange-crowned Warbler	*Vermivora celata*
Nashville Warbler	*Vermivora ruficapilla*
Yellow Warbler	*Dendroica petechia*
Yellow-rumped Warbler	*Dendroica coronata*
Black-throated Gray Warbler	*Dendroica nigrescens*
Common Yellowthroat	*Geothlypis trichas*
Wilson's Warbler	*Wilsonia pusilla*
Blue Grosbeak	*Guiraca caerulea*
Chipping Sparrow	*Spizella passerina*
Brewer's Sparrow	*Spizella breweri*
Lark Sparrow	*Chondestes grammacus*
Savannah Sparrow	*Passerculus sandwichensis*
Lincoln's Sparrow	*Melospiza lincolnii*
White-crowned Sparrow	*Zonotrichia leucophrys*
Red-winged blackbird	*Agelaius phoeniceus*

Appendix 1. continued

Tricolored Blackbird	*Agelaius tricolor*
Western Meadowlark	*Sturnella neglecta*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
Brewer's Blackbird	*Euphagus cyanocephalus*
Brown-headed Cowbird	*Molothrus ater*
House Finch	*Carpodacus mexicanus*
Lesser Goldfinch	*Carduelis psaltria*
House Sparrow	*Passer domesticus*

DEPARTMENT OF ENERGY
SAN FRANCISCO OPERATIONS OFFICE

CONTRACTOR REQUEST FOR PATENT CLEARANCE
FOR RELEASE OF UNCLASSIFIED DOCUMENT

Prime Contract No.	DE-FC03-77SF10501
Subcontract No.	(N/A)
Report No.	DOE/SF/10501-306 (STMPO-606)
Date of Report	January, 1984
Name & Phone No. of DOE Technical Representative	S. D. Elliott, Jr. (619) 254-2672

TO: Roger S. Gaither, Asst. Chief for Prosecution
Office of Patent Counsel/Livermore Office
P.O. Box 808, L-376
Livermore, California 94550

FROM: DOE Project Office, Barstow
Post Office Box 366
Daggett, CA 92327

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WILDLIFE INTERACTIONS AT SOLAR ONE: FINAL REPORT

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Signature S D Elliott Jr. Date FEB 20 1984

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U.S. DEPARTMENT OF ENERGY

memorandum

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TO: Roger Gaither, DOE/SAN (OPC)
William Matheny, DOE/TIC Document Control
DOE/SAN Mail & Records

Attached are copies of a recent report prepared by Southern California Edison Company under the subject Cooperative Agreement:

DOE/SF/10501-306 (STMPO-606) "Wildlife Interactions at Solar One: Final Report", January, 1984

One copy, accompanied by SAN Form 70, is for review and clearance by the SAN Office of Patent Counsel. Upon completion of review, it is to be forwarded with a copy of this memo, to SAN Mail & Records for the contract file.

Two copies, accomanied by DOE Form RA-426, are provided for archiving and announcement by DOE Technical Information Center and forwarding to NTIS.

S. D. Elliott, Jr.

cc: Bob Hughey, DOE/SAN (FGS)
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C. W. Lopez, SCE R&D
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